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B. T. GALLOWAY, *Chief of Bureau.*

SAP-ROT AND OTHER DISEASES OF THE RED GUM.

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BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 24, 1907.

Sir: I have the honor to transmit herewith a paper entitled "Sap-Rot and Other Diseases of the Red Gum," by Dr. Hermann von Schrenk, formerly expert in charge of the Mississippi Valley Laboratory of this Bureau, and recommend that it be published as Bulletin No. 114 of the series of this Bureau.

Acknowledgment is made of our indebtedness to the Chas. W. Luehrmann Hardwood Lumber Company and to the Indiana and Arkansas Lumber Company, both of whom rendered special assistance in carrying on the work.

The accompanying illustrations are essential to a clear understanding of the text.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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SAP-ROT AND OTHER DISEASES OF THE RED GUM.

INTRODUCTION.

The red gum (*Liquidambar styraciflua*) is a tree which is singularly free from fungous diseases when compared with other species of hardwood trees. This comparative freedom from disease it shares with many other species of more or less ancient geologic lineage.[a]

One of the reasons why the trees are so immune to the attacks of fungi may be sought for in the production of a kind of gum or resin which is present in almost all parts of the trees. The resin appears as a yellowish-brown, semitransparent liquid, with a very bitter taste, in wounds and on the bud scales of our American species. It is commercially known as liquidambar or copal balm. *Liquidambar formosana* produces a similar terebinthinous resin and *L. orientalis* has a similar substance from which the storax, another resin largely used in China, is obtained.

The principal reason for the comparative immunity from disease is probably the fact that in the course of its development from the

[a] The species of Liquidambar date from the Tertiary epoch, during which period one species (*L. californicum*) flourished on the western slopes of the Sierra Nevada in California. "The immediate ancestor of the interesting American species inhabited Alaska, Greenland, and the midcontinental plateau of North America, and later was widely distributed in the Miocene of Europe, where have been found the traces of a second species similar in the form of its leaves to the present representative of the genus in western Asia." (Sargent, C. S., Silva of North America, 5:7; 1903.)

Lesquereux reports the same species from the Miocene from Alaska and the Chalk Bluffs of California.

Lesquereux (The Cretaceous and Tertiary Floras; Rep. U. S. Geol. Survey, 8:159; 1883) reports *L. europaeum* Al. Br. from Wyoming. *L. europaeum* was very common in the Miocene of Europe. Lesquereux also describes *L. integrifolium* Lesqu. from Salina, Kans. (The Cretaceous Flora; Rep. U. S. Geol. Survey, 6:57; 1874.)

At the present time only three species of Liquidambar are known, viz, *L. styraciflua* from the United States, *L. orientalis*, from southwestern Asia Minor, and *L. formosana*, from China and Formosa.

early Tertiary period up to the present time a gradual elimination of those individuals which tended toward becoming diseased has taken place. In other words, the genus has been tending more and more toward becoming immune, because of the survival of such individuals as showed greater immunity to infection by fungi which tend to shorten the life of the trees. The present comparative freedom from serious disease is therefore probably to be explained by a simple process of natural selection, which has produced a race of almost immune individuals. This evolution against disease is one which the red gum shares with many other species of ancient lineage, such as the bald cypress, the redwood, and the sycamore.

The heartwood of the red gum is comparatively long lived when exposed to weathering influences. It has been used for a great many years in the construction of buildings, where it has served for foundation timbers, and in some instances in bridge construction. When thoroughly dried before being exposed, its length of life is comparatively great. Some instances are known to the writer where timbers of heart red gum have served as foundations in sawmills in Arkansas for fifteen years or more. Railroad ties have been made of red gum in the Mississippi Valley for a good many years and have shown a lasting power of from seven to eight years or longer. (Pl. VII, fig. 2.) Even the sapwood, which, as will be seen, is very rapidly destroyed by fungi when in a green condition, can be made to last a long time. See Plate VII, fig. 1, representing a section of a cross-arm, one of many made of red gum which had been in service on an electric-light line in eastern Arkansas for eight years. The country in which these cross-arms were exposed has probably as humid and hot a climate as can be found. In spite of this, the timber shows practically no change after eight years' exposure.

While the live tree shows few diseases, the cut timber, unless properly handled, is very liable to decay. During recent years, with the increased quantity of gum timber cut, a number of serious diseases have caused losses of a severe character every year. In the following pages are described some of the diseases of the living tree and a sap-rot of the structural wood, with suggestions as to methods for preventing the latter.

DISEASES OF THE LIVING TREE.

As has been stated, the living trees of the red gum are generally free from very serious fungous diseases. Those diseases that are present usually manifest themselves in the form of butt-rots. There are no very serious diseases of the tops of the trees nor of the leaves or branches. Of the butt-rots there are several forms which are found almost wholly in older trees. Old trees when cut down will,

in a large majority of cases, be found to have hollow butts. The hollow extends up into the trunk from 2 to 15 or 20 feet. When cut down the interior of the hollow will be filled with a more or less powdery mass of decayed wood, a condition brought about by the joint action of various boring insects and saprophytic fungi. The inner portions of the trunk are generally so thoroughly decayed that it is impossible to recognize any one particular form responsible for the destruction. On the border between the sound wood and the decayed portion a number of definite forms of decay have been noted, several of which are described below.

YELLOW BUTT-ROT.

One of the commonest appearances in the butts of the gum is a form of decay which renders the wood more or less cheese-like in character and turns the heartwood from red to a yellowish brown. The wood is thoroughly permeated by fine strands of white fungous mycelium, which extend both longitudinally and radially throughout the wood. (See Pl. I, fig. 1.) In advanced stages the wood is soft and pulpy and can readily be crumbled into a powdery mass. This form of rot is the most common one in the butts of the trees, and in several instances was found extending up 15 to 20 feet into the tree. In one trunk a fruiting organ was developing in the hollow. The same is a form of Poria. The spores are very short and snow white in color. The hymenium adapts itself to the irregularities of the decaying wood.

A form of decay is produced by *Polyporus lucidus*. The decay resembles that just described and may, in fact, be the same. In the case of one particular stump large sheets of white mycelium formed between various annual rings, and the wood appears very much firmer than that in the yellow butt-rot described above. The fruiting organ of this fungus in one case developed in about two months from the time the trees were cut down. The top surface of the sporophore appears highly varnished, with numerous definitely marked concentric layers. The lower surface is more or less cream-colored to white. When wounded the lower surface turns blood red.

SPECKLED ROT.

A second form of decay which appears very commonly in the hollow butts of trees changes the wood into a porous mass consisting of a large number of small cavities bounded by layers of sound wood. It resembles very much the decay produced in oak by various species of Stereum. This form of decay, while common in the butt, may occur far up into the tree. The tree from which the piece shown in Plate I, figure 2, was taken was decayed entirely into the center, as a result

of which condition the tree had been broken off by the wind at a point about 12 feet from the ground. This form of decay is very distinct from the one just described and will always be known by the peculiar circumscribed holes formed throughout the mass of the wood fibers. Only one fungus has been associated with this form of decay, and it is rather doubtful whether this fungus, a Poria, is responsible for it.

PIPED ROT.

A third form of disease is found in the center of living gum trees. The summer wood appears to be changed into cellulose in regular layers. The wood as a whole has a very bright yellow-brown appearance, evidently due to the mycelium of the particular fungus causing the decay. Only one tree answering this description was found. From its appearance, the disease seemed to extend about seven or eight feet up into the trunk.

LEAF DISEASES.

About eighty species of fungi growing on the leaves and branches of the red gum have been described. Most of these are very inconspicuous, however, and do not cause any very serious damage to the trees. Among them may be mentioned *Valsa liquidambaris* Curtis, *Seiridium liquidambaris* B. & C., and *Septoria liquidambaris* Cook & Ellis.

SAP-ROT.

After the trees of the red gum are cut into logs a number of destructive fungi attack the sapwood with such rapidity that after a very few months the wood is rendered wholly worthless. The red gum shares this susceptibility to rapid decay of its sapwood with many other hardwood and coniferous trees. Of these may be mentioned in particular the tupelo gum, beech, maple, swamp oaks, and loblolly pine. There is a large group of fungi which thrive upon the sapwood of trees after they have fallen and bring about a kind of decay, which may for convenience be called sap-rot. The sap-rot of the gum forms one of the worst defects of this valuable wood and has resulted in very serious commercial losses during late years.

OCCURRENCE OF THE DISEASE.

In many regions where the red gum is cut for its lumber the logs are sawed in the woods and are then skidded either to the railroad or, more frequently, to the bank of some river. Where logs are taken to the mill by means of a railroad and sawed at once the sap-rot usually does not give much trouble. The boards dry out in the piles to such an extent that the growth of the fungus is made impossible. Where logs are rafted, however, the sap-rot will start in the logs,

depending upon the season of the year, from one to several weeks after the logs are cut. When green the red gum has such a large quantity of water in its trunk that it will sink when put into water, and it is therefore impossible to raft green red gum, even with the assistance of lighter species of wood. For this reason the logs are usually piled along the banks of streams for five or six months, or longer, until they have dried out to such an extent that they can be rafted by the aid of cottonwood or other lighter logs. In almost all cases the trees are simply cut down and sawed into the standard lengths (12, 14, and 16 feet). The bark is left on the logs. When skidded along the bank of the river the logs are usually placed in irregular close piles, most of the logs lying directly on the ground.

The sap-rot makes its principal appearance during the months from May to October, and in the extreme Southern States, where the summer temperatures are very extreme, and particularly in the more or less swampy countries where the red gum grows, the development of sap-rot takes place with great rapidity. Logs which are left on the banks of southern streams and examined during the months of July, August, and September will appear blackened on the ends; molds and toadstools of all kinds will be found growing on the ends, while the sap which has exuded will look dark and generally has a sour, more or less acid, odor. The evidences of fermentation due to yeasts and molds of various kinds have given the cut surfaces of the sapwood a black, stained appearance. (See Pl. II, figs. 1 and 2.) Not infrequently the small sawdust piles of a species of bark-boring beetle are more or less evident. Where the sawed ends are pointed so that the sun shines upon them during a large part of the day the logs may not show any evidences of fungi or toadstools, but in almost all cases the sapwood will look stained, and usually black, because of a surface mold. While it is generally realized by lumbermen that the summer months produce an inferior grade of lumber, it has nevertheless not been found possible to restrict the cutting of logs to the winter period. The investment in camps, teams, etc., and the difficulty of obtaining labor unless constantly employed have necessitated operations extending through the entire year. On that account, although the losses due to cutting the timber during the summer months have in many instances been very great, the cutting operations have not been restricted.

When the logs have dried out sufficiently on the banks, they are made into rafts and are towed or floated to the sawmill. This takes place usually during December and January when a sufficient amount of water can be obtained. On arriving at the sawmill it will be found that the summer-cut logs manufactured into boards show a decay which has extended in from both ends of the log

throughout the sapwood for distances varying from several inches to several feet. When it is remembered that the logs are 12, 14, and 16 feet long, and supposing that a log is decayed in from both ends for a distance of 2 feet or more, making 4 feet or more for one log, it will readily be seen that the amount of loss incurred because of this end rot is very considerable.

DESCRIPTION OF SAP-ROT IN BOARDS.

The decayed boards present a very striking appearance. The normal color of the sapwood of the gum is a light straw-yellow, verging in many cases into a color which may be called a light brown. The decayed board is characterized by a series of various-colored streaks or lines distributed in an irregular manner from the end of the log toward the middle. These streaks (shown in Pl. III) are light orange in the region of first change—the region bordering upon the sound wood. When the wood has decayed further, this color changes to a very light straw-color, which is almost white. Mixed in with this white color are distinct lines and patches having a bluish tinge, more properly described as Payne's gray. Here and there sound pieces of the brownish-colored normal wood will appear, and where the decay has proceeded to a considerable extent black zigzag lines, such as are found in many hardwoods, extend from the end parallel to the wood fiber for 2 or more inches into the board. A partially decayed board appears as if irregularly bleached; that is, it looks as if the action of the fungus had destroyed the natural color of the wood fiber, leaving certain decomposition products in the wood which give it the yellow-brown and bluish color. The decay is one of the most striking which have been found in either hard or soft woods and one which it will be almost impossible to mistake when once seen.

The general consistency of the wood is firm and solid; in other words, the preliminary changes resulting in the color changes referred to, while they appear very striking, do not seem to involve any material disintegration of the wood fiber. It is only after the fungus has grown for a considerable distance into the wood—for 2 or 3 feet—that a marked disintegration results. The wood then becomes more or less pulpy and soft and loses its firm character. If left long enough the entire board may become affected, and where logs have been left on the banks of streams or in the woods for a year or more the entire sapwood will become so thoroughly permeated by the mycelium of the fungus that it is practically entirely destroyed.

MICROSCOPIC CHANGES IN DECAYED WOOD.

The microscopic changes in red gum wood due to various forms of sap-rot consist principally in a destruction of the red coloring matter of the wood cells. The affected masses of wood appear bleached, as if the fungus had dissolved the color. After the fungus has grown in the wood for some time, a gradual solution of the cell walls becomes evident. Large masses of brown and colorless fungous threads fill the cell lumen. The details of the changes brought about in the fiber are of minor importance in this connection, and a description will be found elsewhere.

THE FUNGUS WHICH CAUSES SAP-ROT.

Freshly sawed boards which show the discoloration just referred to, when piled in the yard to season, generally contain sufficient water to permit the fungus within the wood fibers to continue its development. It is no unusual sight in piles which contain the partially decayed boards to find the fungus flourishing on the surface of the boards, generally most profusely on the lower side, where the sun can not get at the surface and where there is therefore more or less moisture. After several weeks the threads of the fungus will grow out from the white portions of such boards, and after several additional weeks the fruiting bodies of the fungus will form in long lines on one or both surfaces. (See Pl. IV, fig. 2.) These fruiting bodies will likewise form in considerable number on the ends of affected boards, and in going through a yard there will be found a large number of such boards with the shelf-like fruiting bodies in various stages growing out from the ends. (See Pl. IV, figs. 1 and 3.) In making an examination of the fruiting bodies one will find that there are a number of fungi which apparently flourish in the sap-wood of the red gum and bring about the changes referred to above. The most frequent one is a widely distributed form (*Polyporus adustus*). (Pl. IV, figs. 1 and 2.) This fungus appears in the form of small shelves, either singly or in groups, depending upon whether they form on the side or the end of the planks. Where a plank is lying horizontally the fungus may appear in the form of extended sheets, one margin of which will be slightly turned at an angle of 90° to the surface of the board, forming a partial pileus. (Pl. IV, fig. 2.) Where a large amount of moisture is available in the boards or timbers the fungus may form large sheets from which horizontal shelves will project which bear the hymenial layer. The shelves of this fungus vary in size from the smallest specks (see Pl. IV, figs. 1, 2, and 3) to extensive bodies 2 inches in width. The average size, however, is about a half inch in width and about the same in depth.

The normal fruiting bodies are pale yellow in color on the top and a dusky brown on the lower side of the shelves. The young fruiting bodies are almost orange in color. The top surface in the young fruiting body is very soft and woolly. As the fruiting body becomes older this woolliness becomes more distinct, and in the older forms the top may be entirely woolly. There are, on the other hand, numerous forms which are almost smooth. Where the fungus develops on the underside of trunks in the forest or between boards lying one on the other it appears usually in the form of extended sheets, the pores of which point both up and down, depending upon the position of the board. When growing in the forest on old logs the masses of this fungus may be found covering the entire sapwood for areas of several square feet, in which several hundred shelves will be found, all coming from a flattened sheet of tissue. Many of the fruiting bodies will be united more or less, but most of them are perfectly free at the edges. (Pl. II, fig. 2.)

In freshly sawed boards it is not unusual to find more than 75 per cent of the boards in one pile forming the fruiting bodies within two weeks after the boards are piled in the stack. The outside of the board may appear perfectly good, particularly when inspected on the end, and the only evidence that one has to deal with a defective stick will be found in the large number of small shelves which appear on the ends of such boards. The rapidity with which the fruiting organs will form on the board will perhaps be best shown by an experiment made during the past summer. A board, the end of which was covered with thirty or more distinct fruiting bodies, was sawed across at a point 1 inch in from the end, leaving a perfectly smooth surface. Three weeks later this same board was again covered by some thirty or forty fruiting bodies fully formed and mature. This happened during the month of August, 1905.

POLYPORUS ADUSTUS.

Boletus adustus Willd. Fr.[a] (Flora Berol., p. 392, 1787).
Polyporus adustus (Willd.) Fries (Syst. Myc., 1: 363; 1821).

The fungus which causes the sap-rot of the red gum has been found on almost all deciduous woods. So far as known, it does not grow on coniferous woods. It has been reported as growing on the wood of maple, alder, birch, ironwood, chestnut, beech, ash, hickory, walnut, red gum, mulberry, magnolia, sycamore, poplar, oak, locust, willow, tulip, and elm. It probably grows on fallen wood of other hardwood trees.

[a] Only a partial citation of the synonymy of the various fungi growing on gum is made in this bulletin. The full discussion of this subject will be found elsewhere.

Polyporus adustus has been found practically all over the world in the temperate zones. It is one of those fungi which are not adapted to any particular species of wood, but flourish in almost all hardwoods of the temperate zones. It is known to occur in Patagonia and the Argentine Republic in South America. In Europe it has been found in Switzerland, England, Norway, France, Holland, Finland, Denmark, and Russia. In Australia it is reported from New South Wales and Queensland. In North America it grows in Cuba, Canada, and the United States. In the United States it has been found in most of the States east of the one hundredth meridian. West of that line, possibly owing to the prevalence of coniferous forests, it is not reported.

In the forests of the southern United States *Polyporus adustus* is one of the commonest of forms. In the regions where the investigations herein outlined were conducted fruiting bodies of this fungus were common on many tops and branches of the red gum. They were particularly prevalent on tops and branches of trees which had been sawed during the months of April, May, and June. An examination made in this region in October showed that on a large number of the tops sawed several months previously enormous masses of the fruiting bodies of *Polyporus adustus* abounded. (See Pl. II, fig. 2.) It is therefore not surprising that freshly cut trees should become affected with the spores of this fungus within a few days or weeks after the trees are felled. At the period when the logs are felled they are full of water and contain an abundance of organic matter, thereby offering the very best field for the germination and early development of the wood-destroying fungus. The large amount of sugar and other organic compounds present is well evidenced by the prolific development of molds and yeasts on the ends of freshly sawed logs already referred to.

PREVENTIVE MEASURES AGAINST SAP-ROT.

PREVENTION IN THE PILE.

After the fungus has once entered a log it is practically impossible to get rid of it. When infected logs are brought into the sawmill and boards are manufactured therefrom growth will continue in the piles, as already mentioned, unless elaborate precautions are taken to so pile the boards that they will lose their water so rapidly that development is made impossible for the fungus. Various methods have been tried from time to time by lumber companies to prevent the growth of this fungus. A notable one consisted in the application to the ends of affected boards of a thick solution of lime, the idea being that it might thereby be possible to kill the so-called mold within the board.

In a majority of instances applications of this character resulted not only in absolute failure, but hastened the growth of the fungus by preventing the evaporation of water from the ends of the boards. Applications of any chemicals, such as lime, to the outside of boards can not be too strictly condemned.

The only possible way in which the growth of the fungus after it once is in the boards can be stopped is, as already stated, to reduce the quantity of water in the board. In order to accomplish this the boards should be piled in the most open piles which it is possible to construct economically; the spaces between layers should be made at least 1½ to 2 inches. The crossing strips employed should preferably be of some wood other than red gum, possibly oak, and carefully seasoned before being used. The use of crossing strips of red gum brings about a condition in the surfaces which touch one another leading to infection of the crossing strips, which, if used again, may infect boards which up to that time may have been free from the decay-producing fungus. Individual piles should be constructed so as to permit the greatest possible air circulation. At least 8 feet should be left between the piles, and preferably more. Obstructions which would be likely to impede the circulation of the air, such as the use of flat boards for the bracing of runways, should be discouraged. It was found, for example, that in one yard the lower half of the piles, or, more properly stated, that part of the pile below the runway, showed a very much higher percentage of badly decayed boards (boards which had deteriorated over 50 per cent after piling) than did the part of the same pile situated above the runway. In laying out yards care should be taken to so construct them that the prevailing winds blow down the main streets of the yard; in other words, that the direction of the wind shall be across the ends of the boards, i. e., at right angles to the length of the board. Where the wind is allowed to blow in the direction of the length of the board free air circulation is impossible, as the air circulation is constantly impeded by the crossing strips and by succeeding series of piles.

A marked improvement in respect to the rate of development of this and other wood rotting and staining fungi was noted in one yard in which a complete change in the methods of piling, in line with the suggestions just made, was effected. Where crossing strips are to be used again and again it may pay in many instances to treat these chemically with mercuric chlorid. For this purpose a vat made entirely of wood is constructed. No iron should enter into the construction of the vat, as iron is likely to precipitate the mercury from solution. Crossing strips should be piled in this vat and clamped down so that when the solution is run in they may remain submerged. A solution of mercuric chlorid (corrosive sublimate), 1 part of sublimate to 150 parts of water, is then run in and the crossing strips are

allowed to remain in this solution for a period of from seven to ten days. They are then removed and allowed to dry. This treatment will cost about 4½ cents per cubic foot of wood. Crossing strips treated in this manner will practically last an indefinite period of time, and there will be absolutely no opportunity for communicating the infection from board to board.

TESTS MADE FOR PREVENTING SAP-ROT IN LOGS.

In view of the fact that the spores of the rot fungus (*Polyporus adustus*) apparently germinate on the ends of freshly cut logs, it was thought that the application of fungicides of one kind or another to the ends of freshly cut logs might retard the germination of these spores or possibly prevent their germination altogether.

PRELIMINARY TESTS.

In order to test the theory just mentioned a number of living trees were cut near Marianna, Ark., on June 1, 1905, and were sawed into logs 12 feet in length. These 12-foot logs were in turn cut in half, giving two 6-foot logs—a butt and a top piece. The top and butt pieces of each 12-foot log were kept together. One half received treatment and the other half was left untreated. In the following table the 12-foot logs numbered in a series are shown in the first column. The second and third columns give the numbers which were assigned to the 6-foot pieces in the experiment, and show in each case whether it was a top (T) or butt (B).

TABLE I.—*Weights of treated and untreated red gum logs, showing loss of moisture.*

CRUDE PETROLEUM.

No. of log.	Untreated.	Treated.	Original weight, June 2, 1905.	Weight Aug. 7, 1905.	Loss in pounds.	Percentage of loss.	Weight Jan. 15, 1906.	Loss in pounds.	Percentage of loss.
1	10752 T....	.....	375	318	57	15.2	295	80	21.3
1	.....	10753 B....	440	384	56	12.7	362	78	17.7
2	10754 B....	.....	464	405	59	12.7	378	86	18.5
2	.....	10755 T....	411	360	51	12.2	338	73	17.7
3	10756 T....	.....	480	419	61	12.7	397	83	17.3
3	.....	10757 B....	519	444	75	14.4	412	107	20.6
4	10758 B....	.....	535	452	83	15.5	418	117	21.9
4	.....	10759 T....	410	357	53	12.9	338	72	17.5
5	10760 T....	.....	521	441	80	15.3	422	99	19.0
5	.....	10761 B....	608	523	85	13.9	490	118	19.4
6	10762 B....	.....	809	661	148	18.3	610	199	24.6
6	.....	10763 T....	648	542	106	16.4	496	152	23.4
7	10764 B....	.....	426	359	67	15.7	330	96	22.5
7	.....	10765 T....	448	404	44	9.8	378	70	15.6
8	10780 B....	.....	820	694	126	15.4	644	176	21.4
8	.....	10781 T....	651	568	83	12.7	530	121	18.6
9	10782 B....	.....	518	446	72	13.9	402	116	22.4
9	.....	10783 T....	485	417	68	14.0	386	99	20.4
10	10784 B....	.....	645	565	80	12.4	521	124	19.2
10	.....	10785 T....	530	460	70	13.2	428	102	19.2
11	10788 T....	.....	682	567	115	16.9	538	144	21.1
11	.....	10789 B....	850	722	128	15.0	668	182	21.4
12	10790 B....	.....	548	467	81	14.8	442	106	19.3
12	.....	10791 T....	495	436	59	11.9	415	80	16.1

TABLE I.—*Weights of treated and untreated red gum logs, showing loss of moisture*—Continued.

CREOSOTE.

No. of log.	Untreated.	Treated.	Original weight June 2, 1905.	Weight Aug. 7, 1905.	Loss in pounds.	Percentage of loss.	Weight Jan. 15, 1906.	Loss in pounds.	Percentage of loss.
1	10766 B....	.....	518	427	91	17.6	404	114	22.0
1	.....	10767 T....	559	455	104	18.6	460	99	17.7
2	10768 T....	.....	471	405	66	14.0	384	87	18.4
2	.....	10769 B....	460	399	61	13.2	370	90	19.5
3	10770 B....	.....	521	436	85	16.3	403	118	22.6
3	.....	10771 T....	472	405	67	14.2	368	104	22.0
4	10772 B....	.....	779	671	108	13.9	642	137	17.5
4	.....	10773 T....	663	571	92	13.9	520	143	21.5
5	10774 B....	.....	866	731	135	15.6	692	174	20.1
5	.....	10775 T....	938	820	118	12.6	778	160	17.0
6	10776 T....	.....	1,000	849	151	15.1	790	210	21.0
6	.....	10777 B....	998	840	158	15.8	764	234	23.4
7	10778 B....	.....	655	555	100	15.3	510	145	22.1
7	.....	10779 T....	573	502	71	12.4	468	105	18.3
8	10787 B....	.....	920	752	168	18.3	698	222	24.1
8	.....	10788 T....	740	632	108	14.6	562	178	24.0
9	10792 B....	.....	465	404	61	13.1	374	91	19.5
9	.....	10793 T....	430	357	73	17.0	326	104	24.1
10	10794 B....	.....	660	558	102	15.5	527	133	20.1
10	.....	10795 T....	690	606	84	12.2	565	125	18.1
11	10796 T....	.....	705	600	105	14.9	551	154	21.8
11	.....	10797 B....	645	548	97	15.0	505	140	21.7
12	10799 B....	.....	630	538	92	14.6	498	132	20.9
12	.....	10800 T....	525	464	61	11.6	428	97	18.4

Two treatments were used. One set of logs was treated with crude Pennsylvania petroleum and another set was treated with ordinary coal-tar creosote. In each case one half of each 12-foot log was treated with either petroleum or creosote and the other half left untreated.

The treatment was carried out as follows: The petroleum or creosote was heated in a kettle to about 150° F. The liquid was then applied to the ends of the logs with a whitewash brush. Several applications were made in each instance, the second application following the first as soon as the creosote or petroleum had soaked into the log. The logs absorbed both the creosote and petroleum very readily, the petroleum more so than the creosote. The amount of creosote or petroleum used was approximately about 1 pound for each log. Both ends of these 6-foot logs were treated.

The only objection which could be advanced against the end treatment is that the application of the preservative might so retard the evaporation of the water from the ends of the logs that a condition would arise in the wood immediately inside of the treated layer most favorable for the development of the fungous spores, should these have found entrance through the treated layers. The chances for such entrances are decidedly good ones, because the gum logs begin to check very soon after they start to dry.

Several years ago a test was made with loblolly pine cross-ties treated with zinc chlorid and then with creosote to determine whether the water injected into the wood with the zinc chlorid would evapo-

rate through the creosote, and, if so, how rapidly this would take place. The following summarized table shows the results obtained, a thousand cross-ties being used for the test:

TABLE II.—*Weight of railroad cross-ties of loblolly pine at various periods after treatment with zinc chlorid, followed by creosote, showing the rate of evaporation of water.*

Dry weight before treatment.	Weight immediately after treatment.	Weight 5 days after treatment.	Weight 10 days after treatment.	Weight 16 days after treatment.	Weight 30 days after treatment.	Weight 60 days after treatment.	Weight 90 days after treatment.	Weight 123 days after treatment.	Weight 1 year after treatment.
Lbs. 152.4	*Lbs.* 213.3	*Lbs.* 198.8	*Lbs.* 186.9	*Lbs.* 172.3	*Lbs.* 168.8	*Lbs.* 151.4	*Lbs.* 144.4	*Lbs.* 138.9	*Lbs.* 131.7

It appears from this table that the water evaporated through the surrounding creosote layer, and apparently with great rapidity, because sixty days after treatment the ties had lost all of the water injected and weighed as much as they did before the treatment. With these results in mind, it seemed probable that the end treatment of the green gum logs would probably not retard the drying of these logs very materially.

In order to determine, however, whether the application of the petroleum or creosote in any way retarded the rate of evaporation of water from the perfectly green log, all the 6-foot logs were weighed before the treatment. The logs were weighed again August 7, 1905, and for a third time January 15, 1906. The rate of loss of the untreated log and its companion treated log, both coming from the same tree, is shown in Table I.

It will be noted that in some cases the treated log lost more than the untreated log; in other cases the reverse was true. The average loss shows that the treated logs dried out with almost the same rapidity as the untreated ones. This goes to show that the application of a thin layer of petroleum or creosote to the end of the log practically does not retard the evaporation of water, and consequently the chances of fungous infection inside of the treated layer will not be greater in the treated logs than in those that are not treated.

SECOND SERIES OF TESTS.

A second series of tests was made in the forest near Levesque, Ark., on August 1, 1905. A series of freshly cut gum logs was selected on the skidway and provided with numbers. In one series the ends of all the logs were painted with creosote. Another set of logs on a subsequent date was painted entirely with petroleum. A third series was untreated. In the fourth series only the sap portion of the end was treated with petroleum, and the fifth series of experiments con-

sisted of painting only the sapwood with creosote. The bark was left on the logs in all cases, and after the treatment the logs were left on the ground near the river, pointing north and south. (Pl. V, fig. 1.)

The following table shows the number of logs treated and the manner of treatment:

TABLE III.—*Number of red gum logs receiving various treatments, August 1–5, 1905.*

	Logs.
Creosoted all over, Nos. 23525 to 23552	28
Creosoted, sapwood only, Nos. 23553 to 23558	6
Oiled all over, Nos. 23559 to 23573	15
Oiled, sapwood only, Nos. 23574 to 23591	18
Creosoted, sapwood only, Nos. 23592 to 23602	11
Oiled, sapwood only, Nos. 235603 to 235621	19
Untreated, Nos. 23501 to 23524	24

THIRD SERIES OF TESTS.

Believing that no risk would be involved in the treatment on a large scale of freshly sawed logs, the lumber company was advised to treat all of its logs during the past summer with creosote or petroleum. At Levesque, Ark., this treatment was carried out with every log from August to October. It was argued that untreated logs would certainly decay as rapidly as they did during the preceding season; and as the preliminary indications as to loss of water by treated logs showed that the treatment did not retard drying, the treatment could certainly do no more damage than the fungus, and it might do considerable good. On this account all of the logs cut at that point were treated with creosote or with petroleum. All of these logs were piled with those treated in the second series. The number of logs so treated was 1,769, having 605,809 feet B. M., of which half were treated with creosote and the other half with petroleum.

COST OF TREATMENT.

The cost of treatment for the experiment was as follows:

Petroleum treatment.—For this treatment 2 barrels of crude Texas petroleum shipped from Houston, Tex., costing $4.50 a barrel at Houston or $8.35 delivered at Levesque, Ark., were used. In addition to the oil, brushes and pails were used and a man was employed to put on the petroleum. The cost for the treatment may therefore be stated as follows:

Petroleum, 2 barrels, at $8.35 each	$16.70
Brushes and pails	5.00
Labor of 1 man, at $1.25 a day, for 8 days	10.00
Total	31.70
Cost per thousand feet	.1046

Creosote treatment.—For this treatment 2 barrels of coal-tar creosote were used. The cost of this treatment may be figured as follows:

Creosote, 2 barrels, at $5 each, delivered at Levesque	$10.00
Brushes and pails	5.00
Labor of 1 man, at $1.25 a day, for 8 days	10.00
Total	25.00
Cost per thousand feet	.0825

RESULTS OF TREATMENT TO PREVENT SAP-ROT.

The logs which had been treated were left on the river bank during the summer months. There was a heavy rainfall during August and September, and at times it was very hot. The conditions for the development of sap-rot were therefore very good. Two examinations were made of the logs, one in October and one in January.

PRELIMINARY EXAMINATION OF TEST LOGS.

A preliminary examination as to the condition of the logs given various treatments was made on October 31 and November 1, 1905. The following table shows the condition of the logs treated in the first series:

TABLE IV.—*Condition on October 31, 1905, of red gum logs at Marianna, Ark., which had received various treatments.*

Number of half log.	Treatment.	Notes on the condition of individual logs.
10800	Creosote	Free; checks very small.
10799	No treatment	Free; checks small.
10797	Creosote	Both ends free; enormous growths of *Polyporus adustus* all along one side of log.
10796	No treatment	Free; checks small.
10795	Creosote	Free.
10794	No treatment	One small *P. adustus* and much Schizophyllum on both ends.
10793	Creosote	Free; checks small.
10792	No treatment	Lower end of one side in wet sawdust.
10791	Creosote	Free; checks small.
10790	No treatment	Absolutely free from fungus; no checks.
10789	Creosote	Free; checks small.
10788	No treatment	Lots of Schizophyllum; very bad checks.
10785	Oil	Some fungus on one end; checks small.
10784	No treatment	*P. adustus* on one end; sap very black.
10783	Oil	Free; checks very small.
10782	No treatment	Very badly affected with *P. adustus* on one end and also on sides.
10781	Oil	Free; checks very small.
10780	No treatment	Free; checks very small.
10779	Creosote	Free; checks very small.
10778	No treatment	*P. adustus* slight on both ends near bottom; also some Schizophyllum; black sap.
10777	Creosote	Free; practically no checks.
10776	No treatment	*P. adustus* very bad on one end, lower side; sap looks black.
10775	Creosote	Schizophyllum, one spot on one end, checks slight.
10774	No treatment	Black sap; red spots both ends; no fungus.
10773	Creosote	Schizophyllum, one spot on one end; checks slight.
10772	No treatment	Schizophyllum, one spot on one end, checks slight.
10771	Creosote	No fungus; checks slight.
10770	No treatment	No fungus; checks slight.
10769	Creosote	Schizophyllum slight on one end; no checks.
10768	No treatment	Schizophyllum slight on one end; no checks.
10798	Creosote	Free; checks very small.
10787	No treatment	Small Schizophyllum on one end.

TABLE IV.—*Condition on October 31, 1905, of red gum logs at Marianna, Ark., which had received various treatments*—Continued.

Number of half log.	Treatment.	Notes on the condition of individual logs.
10767	Creosote	One very small patch of Schizophyllum on one end; checks slight.
10766	No treatment	One very small patch of Schizophyllum on one end; checks slight.
10765	Crude oil	Sound; no fungus.
10764	No treatment	Schizophyllum very slight on one end; none on other end; practically no checks.
10763	Oil	Schizophyllum very slight on one end; none on other; practically no checks.
10762	No treatment	Schizophyllum on one end; bad checks.
10761	Oil	Schizophyllum slight on one end; checks very small.
10760	No treatment	Schizophyllum on both ends; checks in sap; considerable sap black
10759	Oil	No fungus on either end; checks bad in heart on one end.
10758	No treatment	Enormous development of *P. adustus* on one end; no fruits on the other end.
10757	Oil	Free, and hardly any checks.
10756	No treatment	Free; absolutely no checks.
10755	Oil	Free on both ends.
10754	No treatment	Slight Schizophyllum; checks fairly large.
10753	Oil	Free; absolutely no checks.
10752	No treatment	Slight Schizophyllum; checks fairly large.

In a general way it may be stated that the outside appearance of the logs which had had creosote applied to the ends was superior to those logs which were treated with petroleum or those which had been left untreated. The creosoted ends looked reddish brown and were bright in color, with practically no sign of fungous growth. The logs treated with petroleum had a more or less dark appearance, with small patches of fungous threads here and there, none of which, however, had fruited to any extent when examined. The untreated logs as a rule had a black sapwood. Numerous fruiting bodies of the gray fungus (*Schizophyllum commune*) occurred here and there on the ends of the logs, and in several cases the fruiting bodies of the rot fungus (*Polyporus adustus*) were developing vigorously.

An examination of the logs treated in the second series showed a similar state of affairs. The creosoted logs were very striking in their appearance and could readily be picked out among all of the other logs. Those logs which were treated with petroleum appeared blackened, particularly on those ends which were not exposed to the sun, and many masses of fungous threads were growing on the surface of the sapwood. The odor of the petroleum was very distinct, showing that it was still present in considerable quantity. The untreated logs had unfortunately been coated with creosote about October 15, through a misunderstanding. Their appearance was therefore somewhat misleading, and no indications of fungi could be detected. In order to arrive at some conclusions as to what would have been their appearance had they not been thus coated, careful examination was made of a large number of top and butt logs, cut at about the same time the experimental logs were cut, which had remained in the forest and which were, of course, untreated. The general result of this

examination showed that the ends of such logs as were facing south or southwest were usually very dry and more or less checked. The ends not exposed to the direct action of the sun showed a darkly stained sap ring with the fruiting bodies of the rot fungus (*Polyporus adustus*) developing vigorously, sometimes in but one place and in other cases in ten or twelve places in the sap ring. This indicates that in untreated logs the growth of this fungus must begin very soon after the tree is felled and that a considerable amount of development takes place from August to the end of October, resulting in the formation of large masses of fruiting bodies by the end of that period.

A further difference which was very marked between the treated and untreated logs was the character and extent of the checking. The untreated logs as a rule checked much more than the treated logs. Some of the creosoted ends showed practically no checking, and where there was any checking it was as a rule very slight indeed.

FINAL EXAMINATION OF TEST LOGS.

The test logs were again examined on January 16, 1906. At this time most of the untreated logs showed more or less indication of rot at the ends. A large percentage of the untreated ends had masses of the sap-rot fungus (*Polyporus adustus*) growing profusely, generally near the lower side, where the log was close to the ground. The ends treated with creosote appeared black and smooth, without the slightest sign of fungous development. (Pl. V, fig. 2.) The ends treated with petroleum showed signs of disintegration, and in several cases fruiting forms of various wood-destroying fungi were growing on the treated ends.

The value of the creosote treatment in preventing the growth and development of the sap-rot fungi was shown very strikingly in these treated logs.

It should be noted, however, that almost all of the logs, irrespective of whether they were treated at the ends, showed a development of fruiting forms of the above-mentioned fungus (*Polyporus adustus*) growing out on the sides of the logs, chiefly on that side which touched the ground. In many cases the sheets of the fungus covered the bark for several square feet. When the bark was removed it was found that the wood under it was badly decayed, sometimes going half through the sapwood. Those logs which had been skidded so that the air circulated under them were practically free from fungous growth on the outside, although in several instances evidences were found that the fungus was actually growing under the bark and had simply failed to form fruiting organs on account of the drying out of the bark on the outside. No material difference could

be detected in the various logs treated with the creosote as regards checking. The smaller degree of checking of the end-treated logs compared with those which had not received any treatment was as striking at this examination as it had been in October.

An examination of the second set of logs treated at Levesque was made impracticable on account of the fact that they had been thrown into the water and the ends were generally covered with mud. As these were the logs which were sawed in the mill, however, a good idea as to the effect of the treatment was obtained while the logs were being sawed.

RESULTS SHOWN BY SAWED LUMBER.

The logs which had been treated in August at Levesque, Ark., were made into a raft the latter part of January, 1906. The raft was then towed from the landing to the sawmill. The logs remained in the water altogether for a period of about ten days. On arrival at the sawmill a particular effort was made to saw none but the test logs for two days. As the logs came up on to the log platform in the mill a record of the number was made, and the end of the log was so marked that when any particular log was placed on the saw carriage it was readily identified by the person who stood behind the resaw. Three grades of logs were marked, namely, the untreated logs, those treated with petroleum, and those treated with the creosote oil referred to. Each board as it left either the band saw or the resaw was marked in such a manner that when the boards or other lumber reached the grading table the graders had no difficulty in distinguishing between boards which came from either of the three sets of logs. The entire lot of experimental logs was cut into lumber. At the grading table this lumber was sorted and then placed in separate piles in the yard.

As the end treatment was made with the expectation that the development of the rot fungus might be stopped or at least greatly retarded by the application of the preservative to the ends of the logs, careful observation was made to see how far this treatment had succeeded by observing the logs as they were being sawed by the band saw. From the detailed notes kept at the time, the following general statements may be made: The untreated logs showed in a very striking manner how the fungus had gained entrance through both ends of the log and had grown gradually toward the center. The decay and discoloration extended into the log from either end anywhere from 1 to 3 feet. It certainly averaged 1½ to 2 feet. It was most marked within the first 6 or 8 inches and extended out in the peculiar zigzag lines already referred to. Another point which was noted was that not only did this decay start in from the end, but it was also very

marked for several inches in on all sides of the log except at such places where the bark had been accidentally torn away, particularly after the trees had been felled. The discoloration due to the growth of the fungus through the bark and thence inward through the sapwood varied with the log. Those which had a large percentage of sap showed a more marked degree of discoloration than those with less sap.

The logs which had been treated with petroleum showed the rot even more strikingly than the untreated logs. The first 2 or 3 inches in from the ends of the log were generally stained a dark brown or black. (See Pl. VI, fig. 2.) Going toward the middle of the log from the outer zone the decay followed into the log sometimes 3 feet or more. What has been said for the untreated logs in regard to the decay starting under the bark was true also for the petroleum-treated logs. The general observation made while the logs were being sawed was that the petroleum treatment had been a decided failure; in fact, the petroleum-treated logs seemed to have decayed even more than the logs which had been left untreated.

The logs treated with creosote showed a striking difference compared with both the untreated and the petroleum-treated logs. While the wood was frequently stained for some 2 to 3 inches at the very end, it was very noticeable that the wood beyond this outside stain looked sound and had a normal color. The characteristic discolored streaks found in decayed logs were markedly absent. (Pl. VI, fig. 1.) The decay caused by the entrance of the fungus through the bark, that is, along the sides of the logs, was about the same in the logs treated with creosote as in the untreated and petroleum-treated logs.

The general conclusions drawn from the observations made while the logs were being sawed were as follows:

(1) Decay had taken place with great rapidity in the untreated logs. The evidences of growth of the wood-destroying fungus were very marked on both ends of all logs, extending into the same for an average of about 2 feet.

(2) The logs treated with petroleum were badly stained for several inches in from each end, evidently owing to the growth of certain wood-staining fungi. In addition to the stain these logs were badly decayed at the ends for a distance of 2 feet or more, showing that the petroleum had evidently had no fungicidal value whatever.

(3) The creosote-treated logs were practically sound; in other words, the creosote had retarded or prevented the growth of the fungus, and logs the ends of which had been painted with creosote showed practically no evidences of any decay at either end.

As a result of the observations made while the logs were being sawed the conclusion was drawn that the creosote treatment had prac-

tically prevented the end-rotting of the red gum logs, and had thereby resulted in a considerable saving of lumber. This was very evident, because it was practically unnecessary to trim any of the boards which came from the creosoted logs, whereas the boards which came from untreated or petroleum-treated logs had to be trimmed sometimes for 2 feet or more at each end to cut off the decayed portion.

Because of these preliminary results, the lumber company has since that time been treating the ends of all its logs during the summer months by giving them a coating with coal-tar creosote, essentially as previously described, and the results obtained from the preliminary experiments just described have been borne out practically since that time.

REMOVAL OF BARK AS A PREVENTIVE MEASURE AGAINST SAP-ROT.

The experiments described in the foregoing pages dealt with the sap-rot as far as it attacked the logs from the ends. While the end sap-rot is usually the worst form of this rot, the disease is by no means confined to the cut surfaces of logs. After a log has been lying on the ground for some weeks, the bark dries more or less and small cracks will form here and there. Through these cracks the spores of the sap-rot fungus will enter, and in a short time the fungus will have begun decaying the wood, with this crack as a starting point. Various beetles will puncture the bark shortly after the trunks are felled, and spores will get in through the holes which they make. The bark prevents the evaporation of water from the wood, and after the sap-rot fungus has once entered the wood under the bark it finds almost ideal conditions for the most rapid growth and development. Logs which have been lying in the woods for several months will very frequently be decayed for from 1 to 6 inches through the sapwood, either in spots or throughout the entire length of the log. The longer a log lies in the woods the more advanced the decay will be. The sapwood of many logs will be wholly decayed after six months.

The growth of the sap-rot fungus can be very much retarded, if not entirely prevented, by peeling the logs as soon as possible after they are felled. Logs which have been peeled will dry out very rapidly, and when the outer layers are air-dried the chances for infection by the spores of the sap-rot fungus will have been reduced very materially. The peeling of logs is recommended wherever practicable for logs cut from April to November, the period when the trees are in a growing condition. Logs cut during the late autumn and winter will remain sound so long that peeling may be dispensed with.

REMOVAL OF SAP FROM FRESHLY CUT TREES BY LEAF SEASONING.

As was stated under an earlier heading, the wood of the living red gum is so full of water that it is impossible to float green logs. It is on this account that freshly cut logs have to be kept on the river banks until they are at least partially seasoned. If there was any method by which such logs could be dried out more rapidly, the chances for the development of the sap-rot fungus would be very materially reduced.

It is an old saying among lumbermen that logs can be dried by allowing the leaves to dry on a felled tree before sawing the tree into logs. While the writer has often heard this statement made, as far as it applies to felled logs he has so far been unable to find any place where this method has been or is being put to a practical test. The practice of girdling standing trees has practically the same effect. In the cypress forests of the South the trees are girdled in the early winter so as to cause a partial evaporation from the tops. When these logs are cut during the following summer a sufficient amount of water has evaporated from the standing trunks so that in a majority of cases the logs can be floated.

The red gum is a tree in which the drying out of the trunk by means of the leaves offers particularly favorable conditions. It was noted that when a green tree is cut down the leaves remain stiff and turgid for many days, and this even in the hottest weather in June and July. The explanation of this turgidity may be about as follows: When a tree is cut down the evaporation of water from the leaves will continue for a time, the duration of this evaporation depending upon the amount of water in the leaves. In most broad-leaved trees, owing to the fact that water evaporates from both the upper and lower surfaces, the leaves dry very soon after the tree is cut down. The rate at which water can pass from the smaller branches to the leaf petiole and thence to the leaf is very much slower than the rate at which the water evaporates from the leaf surfaces. As a result the leaves soon drop and dry up. In the red gum, however, only one of the surfaces of the leaf, the lower, is provided with stomates so that the evaporation of water takes place only from one surface and that the most protected one. The rate at which water passes from the trunk to the branches and thence in time to the smaller branches, leaf petioles, and the leaves is evidently very nearly the same as that at which the water evaporates from the leaf surface. For this reason the leaves remain green and turgid for a comparatively long time.

Taking this view of the case, the leaves may, in a crude way, be compared to so many little pumps which are slowly pumping the

water out of the trunks into the branches and out into the air. What the actual rate of evaporation from the leaves is, and how much water is actually removed from the trunks, is as yet unknown. Careful measurements to determine this fact are now in progress.

In order to see whether there was any practical result to be obtained by giving the leaves a chance to pump out as much water as they would, the following experiment was made during the past summer: About twenty-five trees were cut down in August, and instead of sawing the timber into logs immediately after felling them they were left intact until the leaves had become absolutely shriveled and dry. This took some two weeks or more. After that the trunks were cut into logs. These logs were skidded to the river just as other logs were skidded. One or more rolled down the bank, and instead of sinking, as a red gum log usually would after but two weeks' seasoning, these logs floated. They did not float very high out of the water; still they floated. The leaf-seasoned logs were made into a separate raft and were brought to the sawmill. It was noted that they floated 1 or 2 inches higher out of the water than was usually the case.

After they were sawed a number of boards were taken at random from the leaf-seasoned logs and a similar number from ordinarily seasoned logs. These were carefully measured and weighed, care being taken to separate sap and heart boards. The resulting average weights per cubic foot are shown in the following table:

TABLE IX.—*Weight per cubic foot of leaf-seasoned and ordinarily seasoned lumber.*

Leaf-seasoned lumber.		Ordinarily seasoned lumber.	
Sapwood.	Heartwood.	Sapwood.	Heartwood.
Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
57.7	50.0	68.0	61.6

The results in this table show that the boards from leaf-seasoned logs were very much lighter than those from logs seasoned in the ordinary manner. Both heartwood and sapwood of the leaf-seasoned logs are lighter than water.[a] While the experiment is but a crude one, the results obtained therefrom are believed to be absolutely trustworthy. The testimony of experienced mill men who floated the leaf-seasoned logs bears out the evidence shown in the table. It may be objected that it will be an expensive matter to saw down trees and leave them to dry, and then to go back several weeks later to cut off

[a] Water at 62° F. weighs 62.355 pounds to the cubic foot.

the branches. While this is certainly true, the expense may be justifiable if one can reduce the time of holding the logs on the river bank and thereby reduce the chances of fungous attack.

The leaf seasoning may not always be practicable, but the results of the experiments of the summer of 1906 were so encouraging that extensive tests with red gum, tupelo gum, and water oak are now in progress.

OTHER SAP-ROTS OF THE RED GUM.

In addition to the sap-rot described in the preceding paragraphs, there are a number of other fungi which grow on the sapwood of the red gum with great rapidity.

HAIRY SAP-ROT (POLYSTICTUS HIRSUTUS).

Of the more important sap-rots the following may be mentioned:

Polystictus hirsutus (Wulff) Fries.

Boletus hirsutus Wulff Jacquin's Coll., 2: 149; 1795.

Polystictus hirsutus (Wulff) Fries (Syst. Myc., 1:367; 1836).

This fungus resembles in many respects the sap-rot fungus (*Polyporus adustus*) previously described. It appears very much as does this form on the ends of the freshly sawed boards (Pl. IV, fig. 3), on crossing strips, and on timbers. It is easily distinguished from the preceding form, however, by its marked zonated appearance on the upper surface of the fruiting body. The fruiting bodies are very much more distinct, although a large number may occur in groups on the same board, on the sides or on the ends. The upper surface of the fruiting body is very hairy (hence the name of the fungus), and is marked by a series of very distinct concentric zones, the alternate ones being a dark red-brown in color. The intervening ones are a yellowish color. The under side, instead of being a smoky brown, as in *Polyporus adustus*, is light straw-yellow. The pores, which in *Polyporus adustus* are very minute and practically indistinguishable to the naked eye, are very large and distinct in the fruiting body of the *Polystictus hirsutus*. When growing in the forest on tops and branches, this form may grow to be very large, sometimes 1½ to 2 inches in diameter, or even larger. Several hundred fruiting bodies are usually found together on old logs, where they form one of the most common fungi of the hardwood belt. *Polystictus hirsutus*, besides occurring on the red gum, is found on almost all species of oak, hickory, ash, maple, chestnut, and other hard woods. It is widely distributed over the eastern part of the United States and has been reported from South America and from several countries in Europe, Asia, and Australia.

The hairy fungus causes a form of decay in the sapwood of the red gum which is practically indistinguishable from that caused by *Polyporus adustus*. In manner of entering the logs, both through the ends and through the bark of the gum, it is similar to the sap-rot fungus. It differs from the latter in its rate of growth, which is by no means as rapid. In lumber piles it grows vigorously and forms fruiting bodies on the ends of boards, much as has been described for *Polyporus adustus*.

The preventive measures to be taken against this fungus are the same as for the sap-rot fungus. The two usually appear side by side, and for practical purposes they need not be separated.

PORIA SUBACIDA.[a]

The fungus *Poria subacida* Peck is frequently found on red gum boards after they have been stacked in piles. It is particularly common on the crossing strips, which it destroys rapidly. From the crossing strips the threads of the fungus grow into the boards on both sides and form sheets of white felt in the space between the boards and the crossing strip. The color of the red gum is destroyed by this fungus, so that after boards are removed from the stacks they will be discolored wherever they touched a crossing strip. Where boards lie in piles for a longer period this fungus may penetrate throughout the sapwood, which is in time reduced to a spongy, white, decayed mass. In the forest *Poria subacida* is found on old branches and tops. It is not of as much commercial importance, however, as either of the two fungi previously described. Where oak crossing strips are used little trouble should be experienced with this form.

OTHER FORMS CAUSING DECAY OF THE SAPWOOD.

While the four fungi already referred to are the ones most frequently found destroying the sapwood of the red gum, there are numerous others of minor importance. Among those are *Lentinus lecomtei* Fr.; *Lenzites betulina* (L.) Fries; *Lenzites bicolor* Fries; *Lenzites corrugata* Klotsch; *Polystictus cinnabarina* (Jacq.) Fr.; *Polystictus sanguineus* (L.) Meyer; *Schizophyllum commune* Fries; *Poria vaporaria* Fr.; *Polystictus versicolor* (L.) Fr.; *Polystictus gilvus* Schw.; *Polystictus pergamenus* Fr.; *Trametes sepium* Berk.; *Stereum fasciatum* Schw.; *Stereum gausapatum* Fries.

[a] Rept. New York State Botanist, 38: 92; 1884.

DECAY OF THE HEARTWOOD OF THE RED GUM.

As was stated in a previous paragraph, the heartwood of the red gum has a length of life very much greater than is usually believed. While this timber has not been used to any very large extent until recent years, its comparatively high resisting power to atmospheric disintegration and to fungous attack should make it an increasingly valuable wood for many purposes requiring exposure to weathering action. Plate VII, figure 1, shows a section of a cross arm which had been exposed on an electric light line for eight years. It will be noted that the arm is still in almost perfect condition. Plate VII, figure 2, shows a section of a red gum cross-tie which had been in constant service in a road in northern Louisiana. About 1,500 ties of heart red gum were laid in 1897. After five years 30 per cent were removed, and at the end of six years 15 per cent more were taken out. In the year 1906 there were 20 per cent still in service. The average life, therefore, was about 7½ years. This is practically as long and, in fact, somewhat longer than white oak would have lasted, when one takes into account the fact that the region where the ties were in service is one of high rainfall and subtropical temperature. The section of cross-tie illustrated in Plate VII, figure 2, shows the beginning of decay at the bottom, but the wood is still comparatively sound for the larger part.

Similar instances of long life have been frequently recorded for the heartwood of the gum where it has been used for paving blocks, foundation timbers, piling, and other purposes requiring longevity. So far as known to the writer there is only one fungus which actively attacks the heartwood and destroys it, and this form does not seem to be at all common. The decay induced by *Lenzites vialis* Peck changes the wood of the gum into a dry, brittle mass, which can be rubbed into a fine powder when pressed between the fingers. The spores of the fungus enter the wood through season checks. On Plate VIII, figure 1, is shown an end view of a tie which had served a great many years in one of the southern railroads. The fruiting bodies of the fungus are developed on this timber. Plate VIII, figure 2, shows a section of this tie 6 inches in from the end. It will be noted that it is almost entirely decayed, with the exception of the region immediately exposed to the air.

Of other heart-rot fungi, only two need be mentioned: *Polyporus lacteus*, and what appears to be an undescribed species of Trametes.

SAP-ROT OF THE TUPELO GUM, SWAMP OAK, AND MAPLE.

The sapwood of many other trees is destroyed by various fungi in a manner very similar to that described for the sapwood of the red gum. In the region of the Mississippi Valley the timbers which

are particularly affected by the sap-rot in addition to the red gum are the tupelo gum, swamp oak, and maple. Of these three timbers, the tupelo gum is the one which is most seriously affected. The trees are attacked by a number of sap-rotting fungi very shortly after they are felled, particularly if the trees are cut in the months from March to October. The rate of destruction of the sapwood by these fungi far exceeds that found for the sapwood of the red gum. The destruction of the sapwood of the tupelo gum by these fungi is so serious that it has been found impossible to pile logs of tupelo gum on the banks of southern rivers for the purpose of drying them so that they can be floated during the months from March to October; wherever such piling has been tried the sapwood has rotted so rapidly that the timber was rendered practically valueless. The fungi which are pacticularly active in destroying the sapwood of the tupelo gum are the following: *Polyporus hirsutus*, *Polyporus versicolor*, and *Polyporus cinnabarina*. Extensive experiments are now in progress, the object of which will be to devise a method for reducing the destructive effects of these forms.

SUMMARY AND RECOMMENDATIONS.

1. The sapwood of the red gum is destroyed with great rapidity by several sap-rotting fungi. The decay caused by these fungi may be called "sap-rot."

2. These fungi grow most rapidly during the spring and summer months. They enter mainly through the ends of logs piled on the banks of rivers.

3. Sap-rot may be prevented by shortening the drying period in the woods, either by hauling logs by rail or by reducing the moisture in the log. This may possibly be accomplished by felling the gum trees without sawing them into logs and leaving them in the forest until the leaves are thoroughly dry. The amount of water evaporated by the leaves before they dry may be sufficient to permit of floating the logs cut from such leaf-seasoned trees.

4. The sap-rot may likewise be almost entirely prevented by coating the ends immediately after the logs are cut with hot coal-tar creosote. The cost of this treatment is about 8 cents a thousand feet, board measure.

5. Wherever possible all freshly cut logs, particularly such as are cut during the spring and summer months, should be peeled.

6. The heartwood of the red gum is comparatively resistant against decay.

7. Sap-rots similar to those which are found in the red gum are found in the tupelo gum, swamp oak, and maple.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Heart-rots of living red gum. Fig. 1.—Radial section of heartwood of red gum affected with yellow butt-rot. Fig. 2.—Tangential section of heartwood of red gum affected with speckled rot.

PLATE II. Untreated red gum logs affected with sap-rot. Fig. 1.—Top of red gum log which has been lying in the woods for two summer months, showing blackened sapwood. Fig. 2.—Red gum log which has been lying in the woods for five warm months, showing large numbers of fruiting bodies of the sap-rot fungus (*Polyporus adustus.*)

PLATE III. Sap-board of red gum affected with sap-rot. The upper part of the figure shows the normally colored wood of the gum. The lower, bleached part of the figure represents the end of the board and shows how the fungus discolors it.

PLATE IV. Fruiting bodies of fungi causing sap-rot of red gum, photographed from boards in lumber piles. Fig. 1.—Sap-rot fungus (*Polyporus adustus*) growing on ends of red gum lumber in pile for eight weeks. Fig. 2.—Sap-rot fungus (*Polyporus adustus*) growing on red gum board in pile for eight weeks. Fig. 3.—Hairy sap-rot fungus (*Polystictus hirsutus*) on red gum in pile for three months.

PLATE V. Red gum logs showing effect of creosote treatment. Fig. 1.—Yard of logs at Levesque, Ark., five months after treatment. Fig. 2.—Logs five months after treatment, showing total absence of sap-rot.

PLATE VI. Red gum boards showing effect of treatment with creosote and with petroleum. Fig. 1.—Two boards cut from different logs treated with coal-tar creosote. The ends of the respective boards face each other. Fig. 2.—Two boards cut from logs treated with petroleum. The ends of the respective boards face each other.

PLATE VII. Heartwood of red gum after eight years' service. Fig. 1.—Section of cross-arm. Fig. 2.—Railroad cross-tie from northern Louisiana.

PLATE VIII. Heartwood of red gum affected with rot. Fig. 1.—Heart-rot fungus (*Lenzites vialis*) growing on heartwood of red gum. Fig. 2.—Cross section of railroad cross-tie made of heartwood of red gum, showing destruction caused by *Lenzites vialis.*

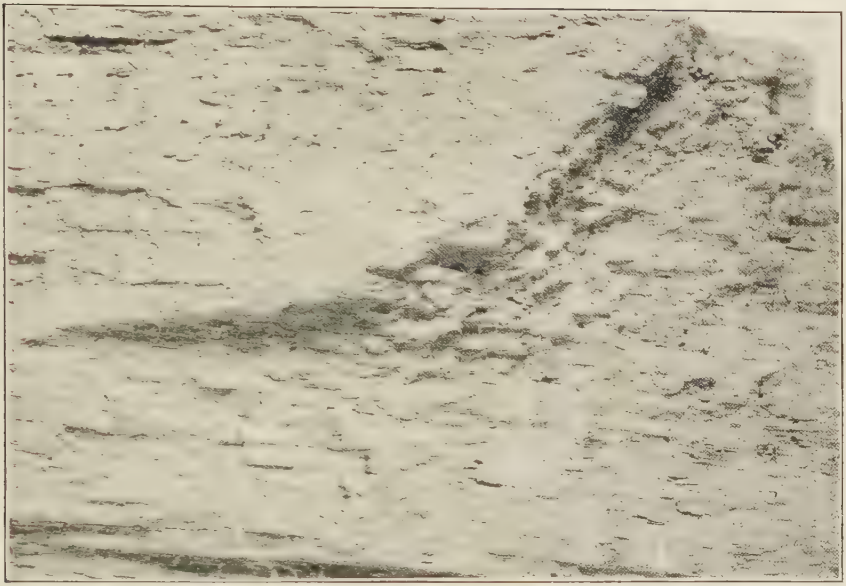

FIG. 1.—YELLOW BUTT-ROT.

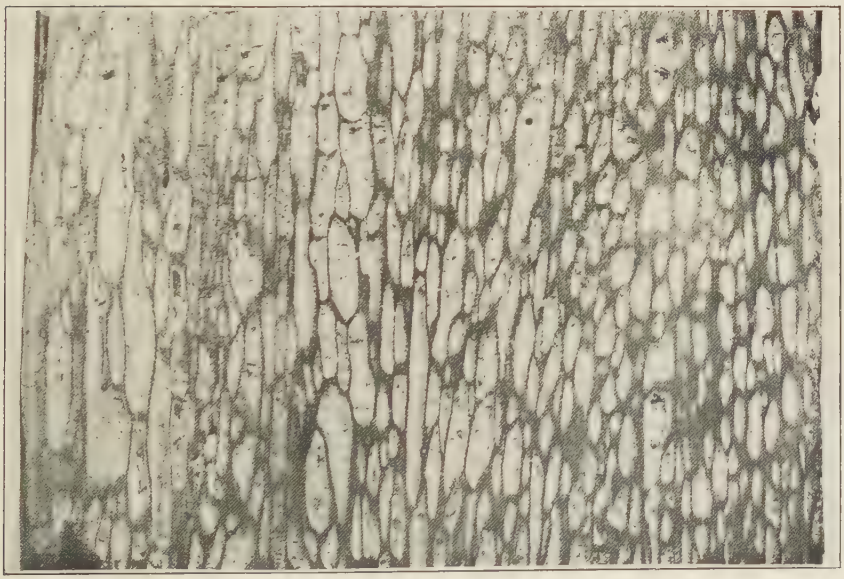

FIG. 2.—SPECKLED ROT.

HEART-ROTS OF LIVING RED GUM.

FIG. 1.—LOG AFTER LYING TWO SUMMER MONTHS IN THE WOODS.

FIG. 2.—LOG AFTER LYING FIVE WARM MONTHS IN THE WOODS.

UNTREATED RED GUM LOGS AFFECTED WITH SAP-ROT.

SAP-BOARD OF RED GUM AFFECTED WITH SAP-ROT.

FIG. 1.—SAP-ROT FUNGUS (POLYPORUS ADUSTUS) GROWING ON THE ENDS OF RED GUM LUMBER IN PILE.

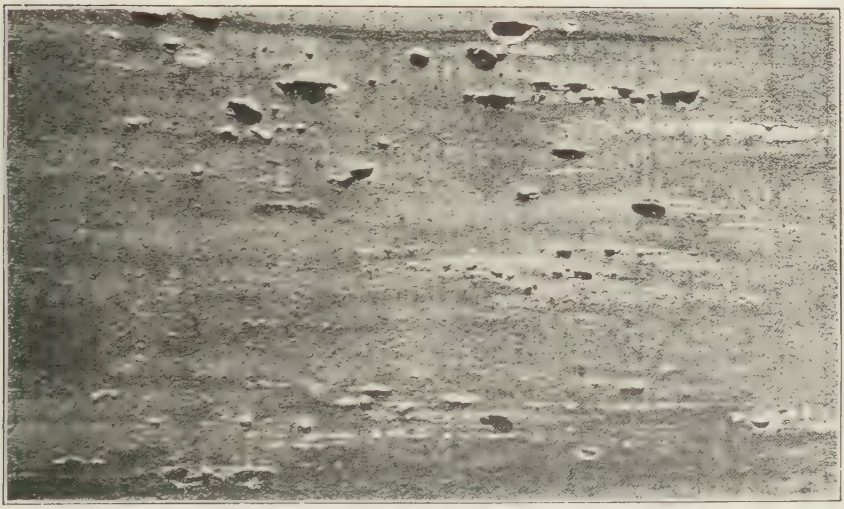

FIG. 2.—SAP-ROT FUNGUS (POLYPORUS ADUSTUS) GROWING ON A BOARD OF RED GUM IN PILE.

FIG. 3.—HAIRY SAP-ROT FUNGUS (POLYSTICTUS HIRSUTUS) ON RED GUM IN PILE.

FRUITING BODIES OF FUNGI CAUSING SAP-ROT OF RED GUM.

FIG. 1.—YARD OF LOGS FIVE MONTHS AFTER TREATMENT.

FIG. 2.—LOGS FIVE MONTHS AFTER TREATMENT, SHOWING TOTAL ABSENCE OF SAP-ROT.

RED GUM LOGS, SHOWING EFFECT OF CREOSOTE TREATMENT.

FIG. 1.—BOARDS TREATED WITH COAL-TAR CREOSOTE.

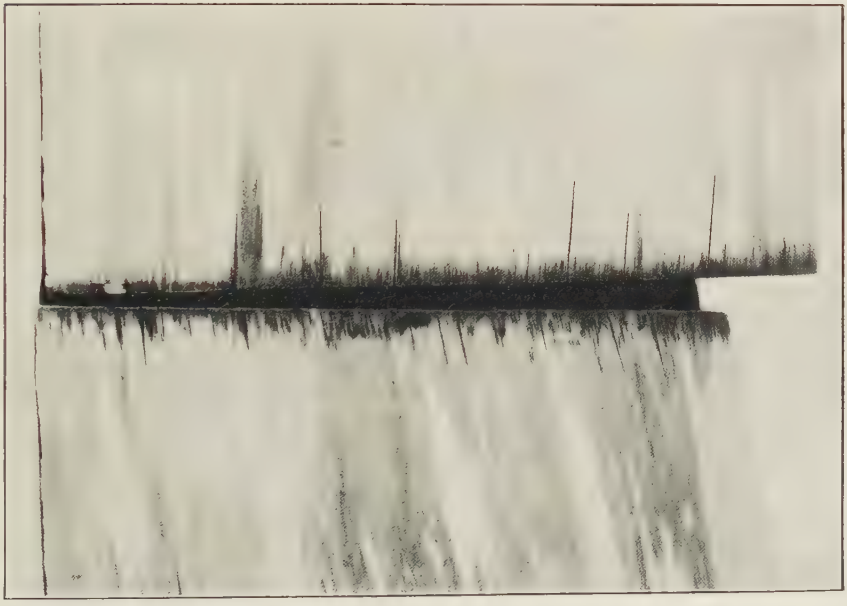

FIG. 2.—BOARDS TREATED WITH PETROLEUM.

RED GUM BOARDS, SHOWING EFFECT OF TREATMENT WITH CREOSOTE AND WITH PETROLEUM.

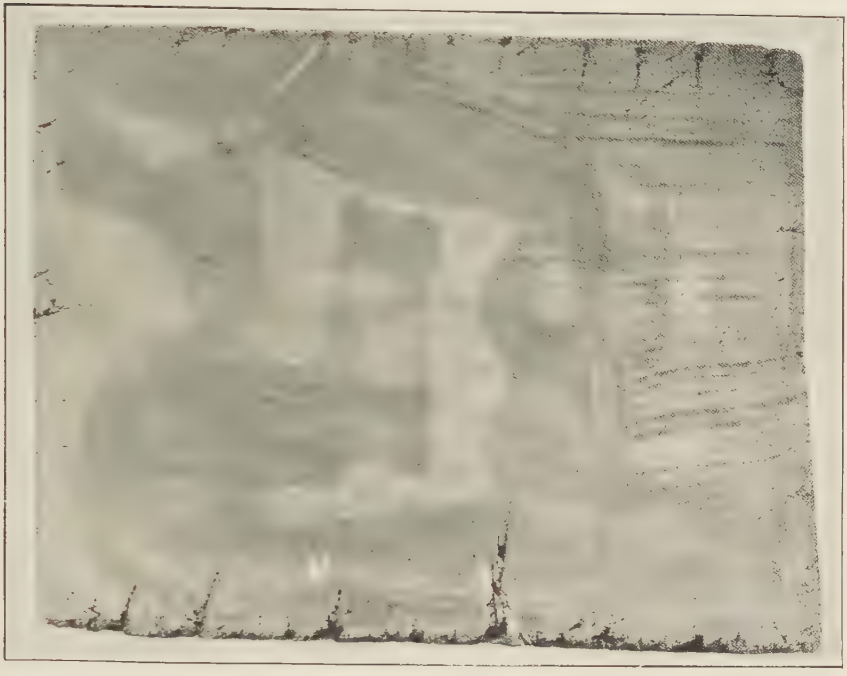

FIG. 1. -SECTION OF CROSS-ARM.

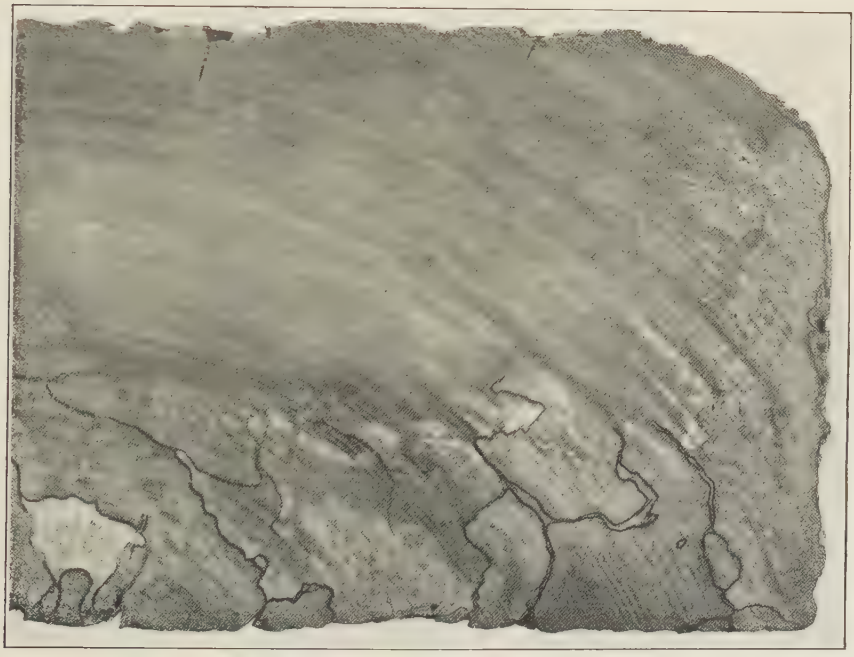

FIG. 2.—RAILROAD CROSS-TIE FROM NORTHERN LOUISIANA.

HEARTWOOD OF RED GUM AFTER EIGHT YEARS' SERVICE.

FIG. 1. HEART-ROT FUNGUS (LENZITES VIALIS) GROWING ON HEARTWOOD OF RED GUM.

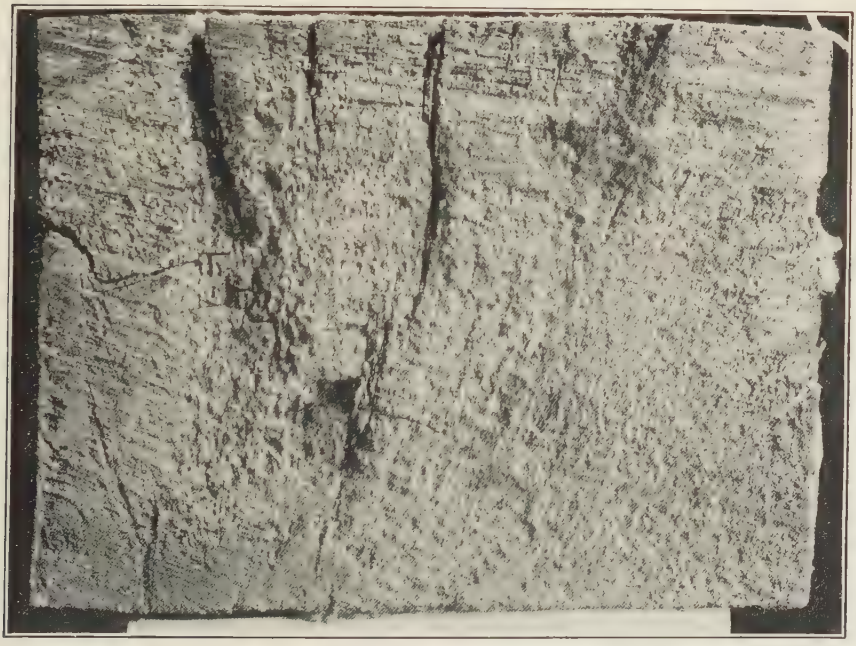

FIG. 2.—RAILROAD CROSS-TIE, SHOWING HEART-ROT CAUSED BY LENZITES VIALIS.

HEARTWOOD OF RED GUM AFFECTED WITH ROT.

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